PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-152577
(43)Date of publication of application : 30.05.2000

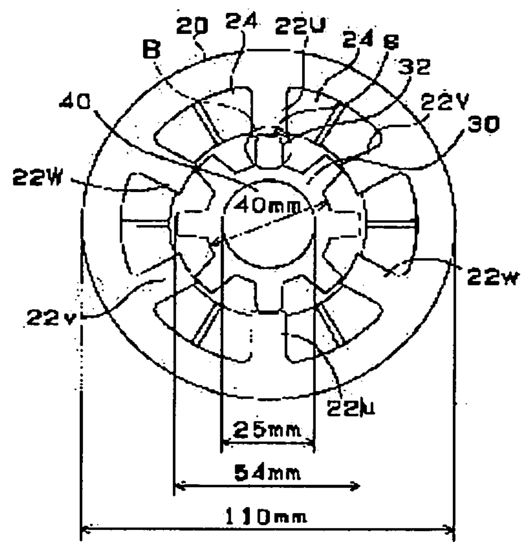
(51)Int.Cl. H02K 19/10
H02K 1/24

(21)Application number : 10-317662
(22)Date of filing : 09.11.1998

(71)Applicant : TOYODA MACH WORKS LTD
(72)Inventor : SAKUGI YASUNORI
YAMAGUCHI SHIGETOSHI

(54) RELUCTANCE MOTOR

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a reluctance motor in which torque ripples are suppressed.
SOLUTION: This reluctance motor consists of a stator equipped with salient poles 22U-22W around which winding 24 is wound, and a rotor 30 equipped with salient poles 32. By imparting a rotation radius to the tip surface S of the salient pole 32 of the rotor 30, the change of inductance of an armature winding 24 is made sinusoidal. As a result, torque ripples can be suppressed so that vibration is not generated when this motor is used in electrically-driven power steering.



LEGAL STATUS
[Date of request for examination]
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] The reluctance motor characterized by attaching the R of bigger curvature than the curvature of the radii centering on the center of rotation to the apical surface of the salient pole in said Rota in the reluctance motor which consists of a stator equipped with the salient pole where the coil was wound, and Rota equipped with a salient pole.
[Claim 2] The reluctance motor characterized by beveling the corner of one apical surface of the salient pole by the side of said stator, and the salient pole in said Rota at least in the reluctance motor which consists of a stator equipped with the salient pole where the coil was wound, and Rota equipped with a salient pole.
[Claim 3] The reluctance motor which sets the outer diameter of a reluctance motor to 70-110mm, and is characterized by attaching to the apical surface of the salient pole in said Rota the R whose radius of curvature is 17-22mm in the reluctance motor which consists of a stator equipped with the salient pole where the coil was wound, and Rota equipped with a salient pole.
[Claim 4] The reluctance motor of claim 3 characterized by setting the radius of the curvature of the salient pole in said Rota to 19-20mm.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the BAIA bull reluctance motor which can be used especially suitable for the drive of electric power steering etc. about a reluctance motor.
[0002]
[Description of the Prior Art] Many DC brushless motors are used as current and a source of power of electric power steering of an automobile. Here, at DC brushless motor, since the permanent magnet which is from a sintered compact on a stator side was arranged, by the heat and vibration which are generated in an engine room, these some permanent magnets suffered a loss, and the missing permanent magnet may have invaded between a stator and Rota, and may have locked the motor. For this reason, use of the reluctance motor which does not use a permanent magnet is considered. A reluctance motor generates torque by passing an exciting current to a coil, when it consists of a stator equipped with the salient pole where the coil was wound, and Rota equipped with a salient pole, the inductance of the coil by the side of a stator changes with reluctance change generated between the salient pole by the side of a stator, and the salient pole in Rota and this inductance is changing.
[0003]
[Problem(s) to be Solved by the Invention] However, when a comparatively big torque ripple is generated, for example, is used for electric power steering, a reluctance motor makes a steering generate vibration and has a technical problem of making a feeling of steering spoil. Current control becomes very complicated although a torque ripple can also be pressed down by adjusting a current command.
[0004] The place which it is made in order that this invention may solve the technical problem mentioned above, and is made into the purpose is to offer the reluctance motor which pressed down the torque ripple.
[0005]
[Means for Solving the Problem] Invention of claim 1 makes it a technical feature to have attached the R of bigger curvature than the curvature of the radii centering on the center of rotation to the apical surface of the salient pole in said Rota in the reluctance motor which consists of a stator equipped with the salient pole where the coil was wound, and Rota equipped with a salient pole in order to attain the above-mentioned purpose.
[0006] Invention of claim 2 makes it a technical feature to have beveled the corner of one apical surface of the salient pole by the side of said stator, and the salient pole in said Rota at least in the reluctance motor which consists of a stator equipped with the salient pole where the coil was wound, and Rota equipped with a salient pole.
[0007] In the reluctance motor which consists of a stator equipped with the salient pole where the coil was wound, and Rota equipped with a salient pole, invention of claim 3 sets the outer diameter of a reluctance motor to 70-110mm, and makes it a technical feature to have attached to the apical surface of the salient pole in said Rota the R whose radius of curvature is 17-22mm.
[0008] Invention of claim 4 makes it a technical feature to have set the radius of the curvature of the salient pole in said Rota to 19-20mm in claim 1.
[0009] In the reluctance motor of claim 1, since the R is attached to the apical surface of a salient pole, change of the inductance of a coil can be made into the shape of a sine wave. For this reason, it becomes possible to press down a torque ripple.
[0010] In the reluctance motor of claim 2, since the corner of the apical surface of a salient pole is beveled, change of the inductance of a coil can be made into the shape of a sine wave. For this reason, it becomes possible to press down a torque ripple.

[0011] Since it is the outer diameter of 70-110mm, the reluctance motor of claim 3 can be used suitable for electric power steering. Moreover, since the radius of curvature has attached to the apical surface of the salient pole in Rota the R which is 16-23mm with the outer diameter of 70-110mm, a torque ripple can be pressed down.
[0012] Since the reluctance motor of claim 4 has set the radius of the curvature of the salient pole in Rota to 19-20mm, it can make a torque ripple min.
[0013]
[Embodiment of the Invention] Hereafter, the reluctance motor concerning the 1st operation gestalt of this invention is explained with reference to drawing. Drawing 1 is A view Fig. of the reluctance motor 10 which shows drawing 2 to drawing 1 by showing the longitudinal section of the reluctance motor [like] 10 the 1st operative condition used for electric power steering, and drawing 3 is drawing taking out and showing only the stator 20 of a reluctance motor, and Rota 30. In addition, by drawing 2 , the right half in drawing is cut and lacked and a stator 20 and Rota 30 are shown.
[0014] As shown in drawing 1 , Rota 30 is supported by the shaft 40 and the stator 20 is held at the inner circumference of housing 50. This shaft 40 is held at the bearings 42 and 44 arranged by housing 50. The coil 24 is wound around the salient poles 22U-22w (refer to drawing 3) of this stator 20. The encoder 52 is connected to the end of a shaft 40 as shown in drawing 1 . Moreover, the flange plate 54 for attaching this reluctance motor 10 in a steering (not shown) side is arranged in one side face of housing 50.
[0015] As shown in drawing 3 , six salient poles 22U, 22u, 22V, 22v, 22W, and 22w which constitute a U-V-W phase, respectively are formed in the inner circumference of a stator 20. Moreover, these salient poles 22U-22w and eight salient poles 32 which counter are formed in the periphery of Rota 30. This reluctance motor 10 is formed in 110mm of appearances, and Rota 30 is formed in 40mm of appearances except the appearance of 54mm, the bore of 25mm, and a salient pole. Both Rota 30 and the stator 20 consist of a 0.5mm laminating steel plate, and it is formed by piling up these 106 laminating steel plates.
[0016] The apical surface S of the salient pole 32 in Rota 30 shown as 'B' in drawing 3 is expanded, and it is shown in drawing 4 . The face width of the salient pole 32 in Rota 30 is formed in 8mm, attaches to an apical surface S the R of curvature which serves as radii with a radius of 13mm from point C' (it sets up every salient pole 32) of the arbitration on Rota 30, and is formed in it. In addition, with this operation gestalt, since Rota is constituted from piling up a laminating steel plate, an apical surface S can be made into the configuration of arbitration. The broken line shows the semicircle with a radius of 27mm (diameter of 54mm) from the center of rotation C of a reluctance motor all over drawing.
[0017] In the reluctance motor concerning the conventional technique, the apical surface of the salient pole in Rota was formed so that the semicircle shown with a broken line might be met. That is, it was formed so that an air gap with salient pole 22U by the side of a stator 20 (refer to drawing 3) might become homogeneity in a radial direction.
[0018] The self-inductance property of the armature coil to the angle of rotation measured by the impedance method for a plane 1 of a reluctance motor equipped with the salient pole of this conventional technique (it asks for a self-inductance from the impedance measured when the single-phase alternative current of commercial frequency is applied to a coil) is shown in drawing 5 (A).
[0019] Here, in the corner of salient pole 22 U-W and a salient pole 32, although an impedance changes with change of the relative position of the salient pole 32 in Rota 30, and salient pole 22 U-W by the side of a stator 20, since an impedance does not change smoothly, as shown all over drawing, the impedance is changing in the shape of a trapezoidal wave. That is, harmonic content is contained in the inductance of an armature coil. For this reason, when the current which changes in the shape of a sine wave was added to a coil, the torque ripple accompanying this harmonic content was generated, and vibration was given to electric power steering.
[0020] On the other hand, with this operation gestalt, the R of bigger curvature than the curvature of the radii centering on the center of rotation C is attached to the apical surface S of the salient pole 32 in Rota 30. For this reason, in the corner of salient pole 22 U-W and a salient pole 32, an impedance can be changed smoothly. The self-inductance property of the armature coil to the angle of rotation measured by the impedance method for a plane 1 of this reluctance motor 10 is shown in drawing 5 (B).
[0021] In the configuration of this operation gestalt, as shown in drawing 5 (B), the impedance is changing in the shape of a sine wave, and big harmonic content is not contained in the inductance of the armature coil 24.
[0022] Here, the generating torque by the reluctance motor 10 of this 1st operation gestalt is explained with reference to drawing 6 . Drawing 6 (A) shows the wave which differentiated the inductance of a coil

mentioned above with reference to drawing 5 (B). Here, a continuous line shows the inductance for U phase (coil of salient poles 22U and 22u), the chain line shows a part for V phase (coil of salient poles 22V and 22v), and the alternate long and short dash line shows a part for W phase (coil of salient poles 22W and 22w). As shown all over drawing, the wave which differentiated the inductance of a coil has also become sine wave-like.
[0023] Drawing 6 (B) shows the armature current impressed to a coil, in the continuous line, the chain line shows a part for V phase, and the alternate long and short dash line shows W phase for a part for U phase. Force current is a sine wave as shown all over drawing.
[0024] Drawing 6 (C) shows the torque generated in a reluctance motor 10. Here, the torque for one phase can be expressed with a degree type.
T=(1/2) i2and**L/**theta -- here -- a T:torque i:armature current L:armature inductance theta:Rota angle of rotation (electrical angle)
All over drawing, the continuous line shows the torque of the reluctance motor 10 with which in the chain line the alternate long and short dash line doubled a part for W phase, and the two-dot chain line doubled U phase, V phase, and W phase for a part for V phase for a part for U phase. As the two-dot chain line in drawing shows, the torque of a reluctance motor 10 becomes straight line-like, and has not produced the torque ripple.
[0025] Then, the result of having carried out the simulation of the value with the suitable radius R of the curvature of the apical surface S of the Rota 30 side-impact pole 32 of a reluctance motor is explained with reference to drawing 7 . Here, the simulation (FEM analysis) was carried out supposing the diameter (outer diameter) of 70-110mm which can be used as a driving source of electric power steering of an automobile about the salient pole structure (salient pole width of face of 15mm) of the reluctance motor of a three phase circuit and eight salient poles.
[0026] Here, drawing 7 (A) is the explanatory view of the salient pole in Rota, and drawing 7 (B) is a graph which shows the square of a difference with the sine wave by the radius R of the curvature of the apical surface S of a salient pole. As shown all over drawing, a difference with a sine wave can be made small by setting the radius R of curvature to 17-22mm. Furthermore, it turns out by setting the radius R of curvature to 19-20mm that a difference with a sine wave is made to min.
[0027] With the operation gestalt mentioned above, the R of bigger curvature than the curvature of the radii centering on the center of rotation was attached to the apical surface of the salient pole in Rota. Also by beveling the corner of the apical surface of Rota, change of an inductance can be made into the shape of a sine wave, and, instead, a torque ripple can be mitigated.
[0028] With this operation gestalt, since the reluctance motor which does not use a permanent magnet is used as a driving source of electric power steering, the dependability of electric power steering can be raised. Moreover, since the torque ripple of a reluctance motor is mitigable, spoiling the steering filling of electric power steering with a torque ripple is lost.
[0029] Then, the reluctance motor concerning the 2nd operation gestalt of this invention is explained with reference to drawing 8 . With the 1st operation gestalt mentioned above, although the R was attached to the apical surface S of the salient pole 132 in Rota, in the 2nd operation gestalt, an R is attached to the apical surface S2 by the side of the salient pole 122 by the side of a stator, or it has beveled to the corner C1. In addition, with this operation gestalt, since a stator is constituted from piling up a laminating steel plate, the apical surface S2 of a salient pole can be made into the configuration of arbitration.
[0030] Also in the 2nd operation gestalt, in the corner C of the salient pole 122 by the side of a stator, and the salient pole 132 in Rota, the impedance of an armature coil can be changed smoothly, and is accumulated and it becomes possible to mitigate the torque ripple of a reluctance motor.
[0031] Then, the reluctance motor concerning the 3rd operation gestalt of this invention is explained with reference to drawing 9 . With the 1st operation gestalt mentioned above, although the R was attached to the apical surface S3 of the salient pole 232 in Rota and the R was attached to apical surface S4 by the side of the salient pole 222 by the side of a stator with the 2nd operation gestalt, in this 3rd operation gestalt, an R is attached for the stator side impact pole 222 and the Rota side impact pole 232, or it has beveled to the corner C2. In addition, with this operation gestalt, since Rota and a stator are constituted from piling up a laminating steel plate, the apical surface S3 of a salient pole and S4 can be made into the configuration of arbitration.
[0032] Also in the 3rd operation gestalt, in the corner C2 of the salient pole 222 by the side of a stator, and the salient pole 232 in Rota, the impedance of an armature coil can be changed smoothly, and is accumulated and it becomes possible to mitigate the torque ripple of a reluctance motor. In addition, in the

reluctance motor of the 3rd operation gestalt, since the configuration of apical surface S4 of the salient pole 222 by the side of a stator and the apical surface S3 of the salient pole 232 in Rota can be adjusted, the inductance of an armature can be brought most close to a sine wave, and it becomes possible to lose a torque ripple nearly completely.

[0033]

[Effect of the Invention] As mentioned above, in the reluctance motor of claim 1, since the R is attached to the apical surface of a salient pole, change of the inductance of an armature coil can be made into the shape of a sine wave. For this reason, when it becomes possible to press down a torque ripple and is used for electric power steering, producing and cheating out of vibration is lost. Furthermore, since a permanent magnet is not used while being able to manufacture electric power steering at a low price, since the reluctance motor is simple as compared with DC brushless motor, dependability can be raised.

[0034] In the reluctance motor of claim 2, since the corner of the apical surface of a salient pole is beveled, change of the inductance of an armature coil can be made into the shape of a sine wave. For this reason, when it becomes possible to press down a torque ripple and is used for electric power steering, producing and cheating out of vibration is lost. Furthermore, since a permanent magnet is not used while being able to manufacture electric power steering at a low price, since the reluctance motor is simple as compared with DC brushless motor, dependability can be raised.

[0035] Since it is the outer diameter of 70-110mm, the reluctance motor of claim 3 can be used suitable for electric power steering. Moreover, since the radius of curvature has attached to the apical surface of the salient pole in Rota the R which is 16-23mm with the outer diameter of 70-110mm, a torque ripple can be pressed down.

[0036] Since the reluctance motor of claim 4 has set the radius of the curvature of the salient pole in Rota to 19-20mm, it can make a torque ripple min.

[Translation done.]

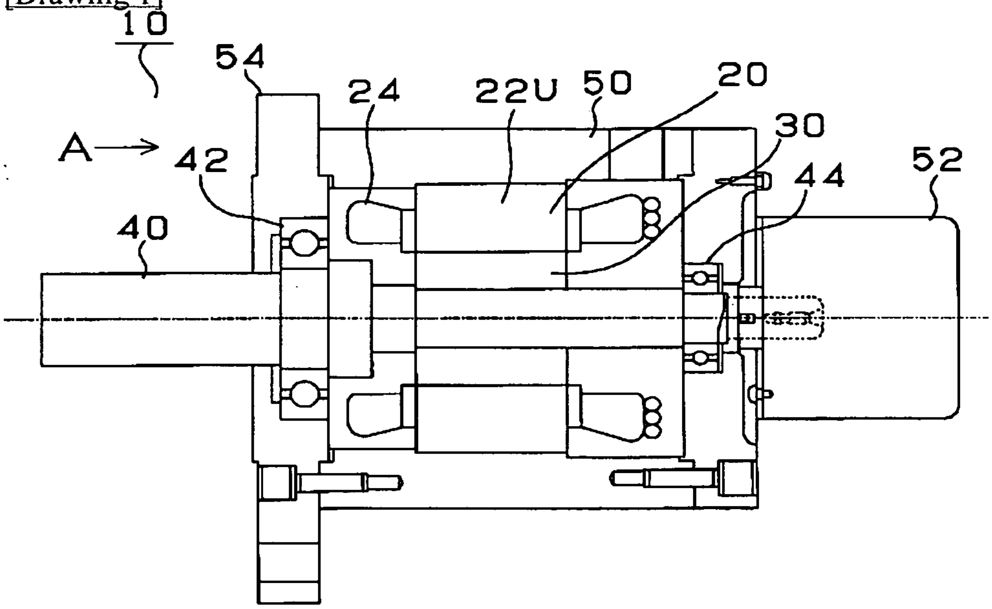
* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

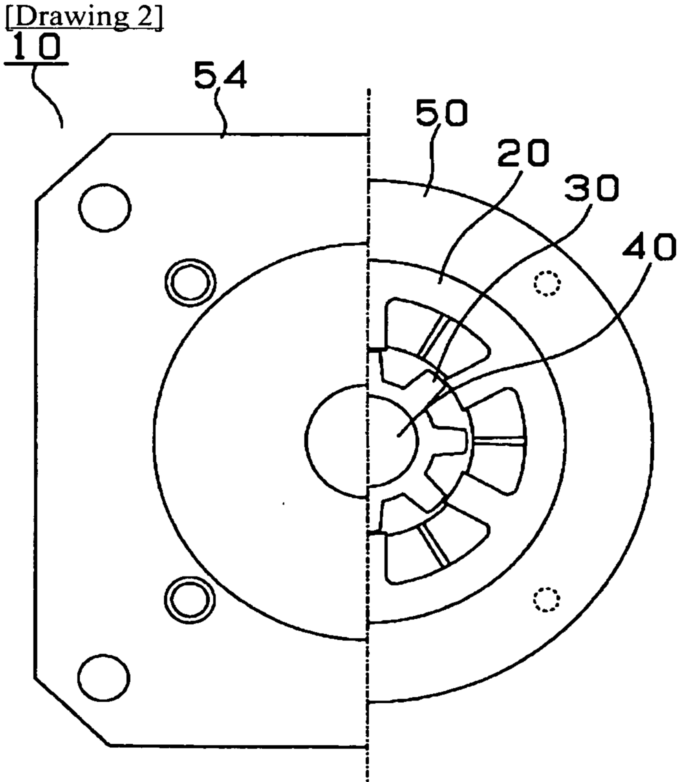
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

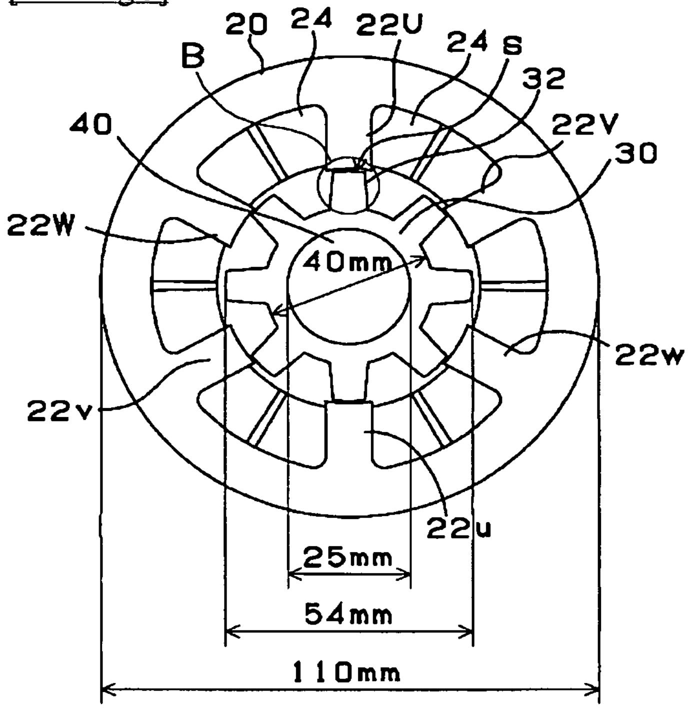
[Drawing 1]



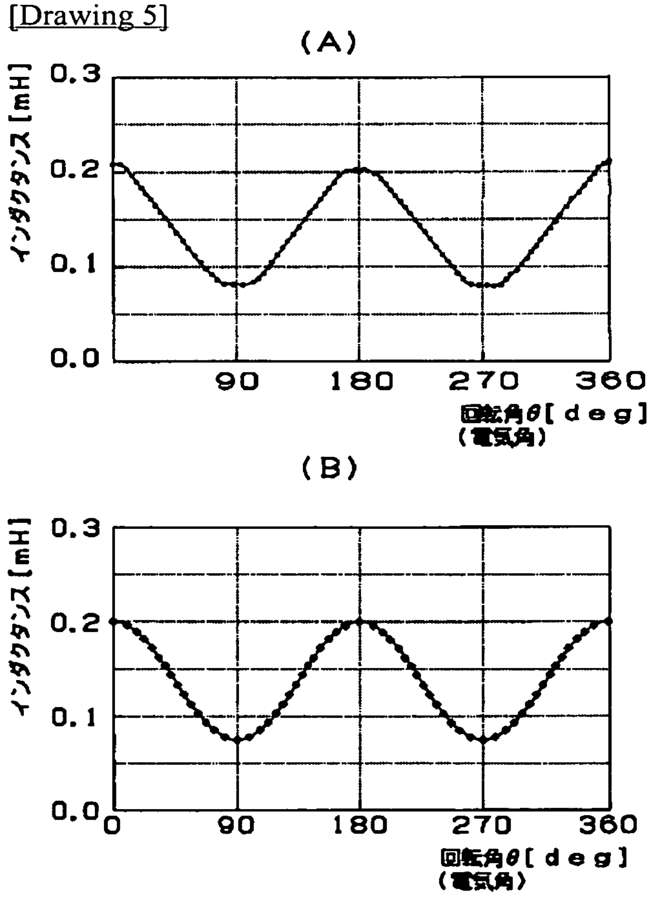
[Drawing 2]



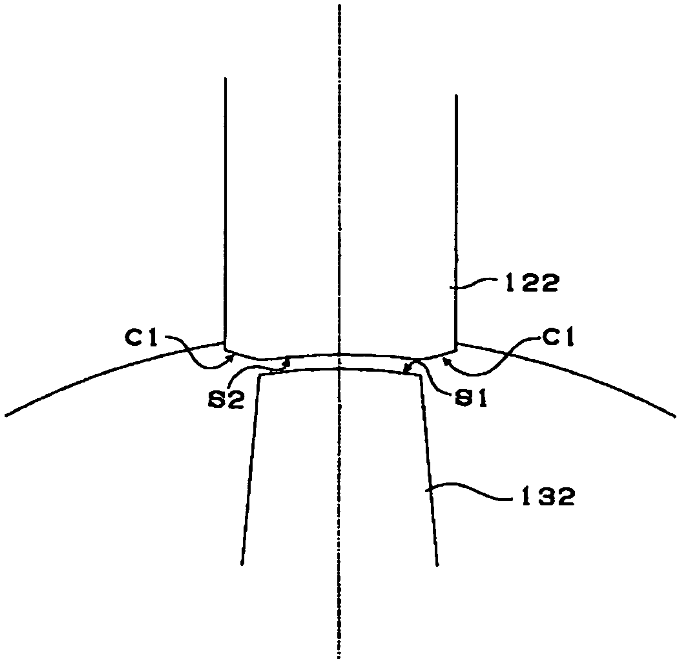
[Drawing 3]



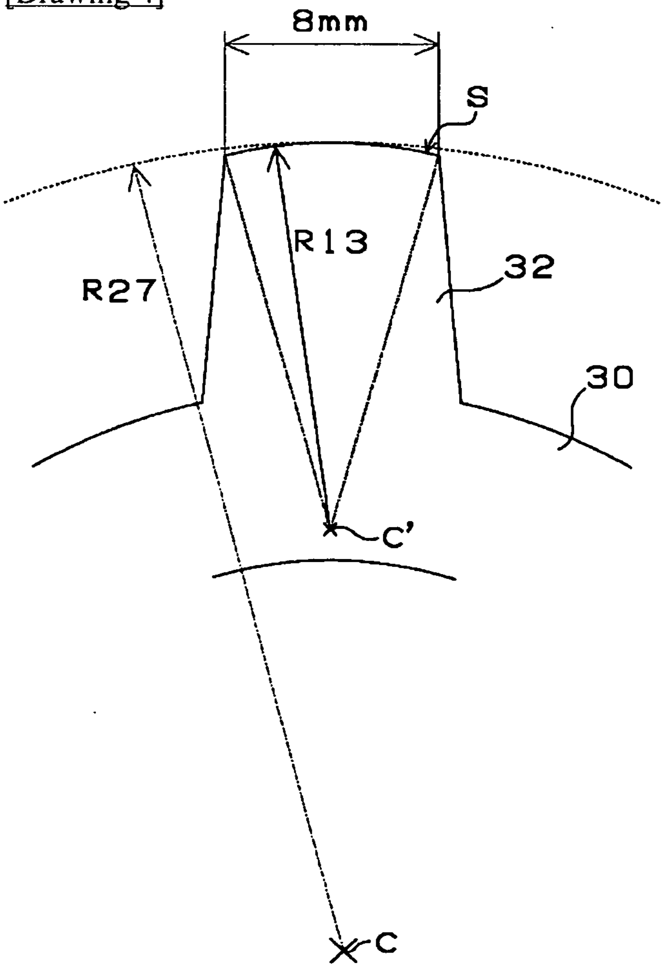
[Drawing 5]



[Drawing 8]

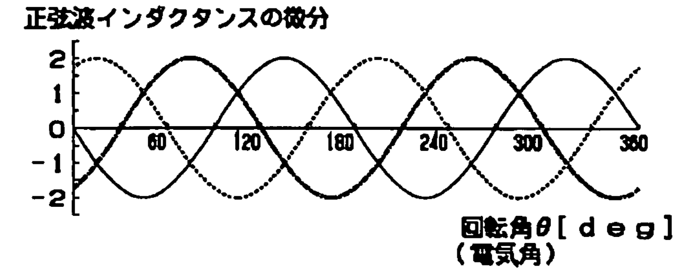


[Drawing 4]

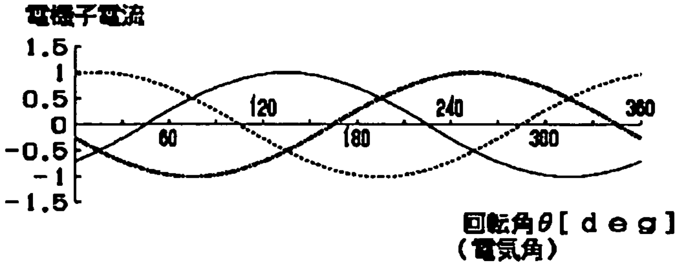


[Drawing 6]

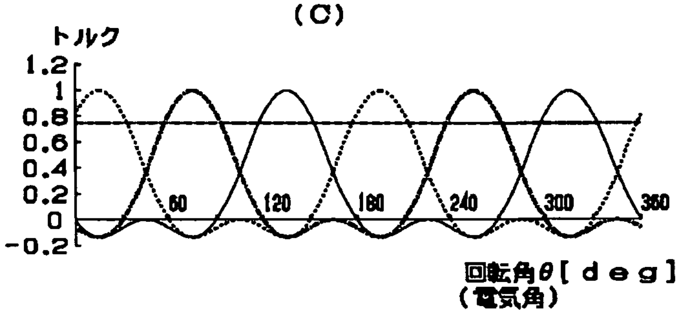
(A)



(B)

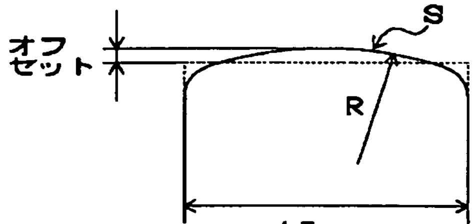


(C)

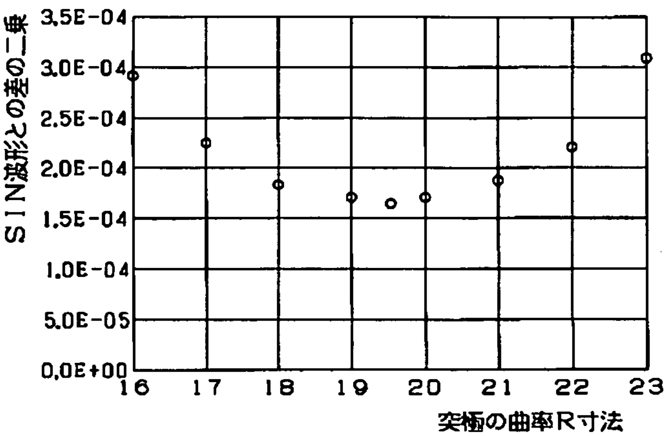


[Drawing 7]

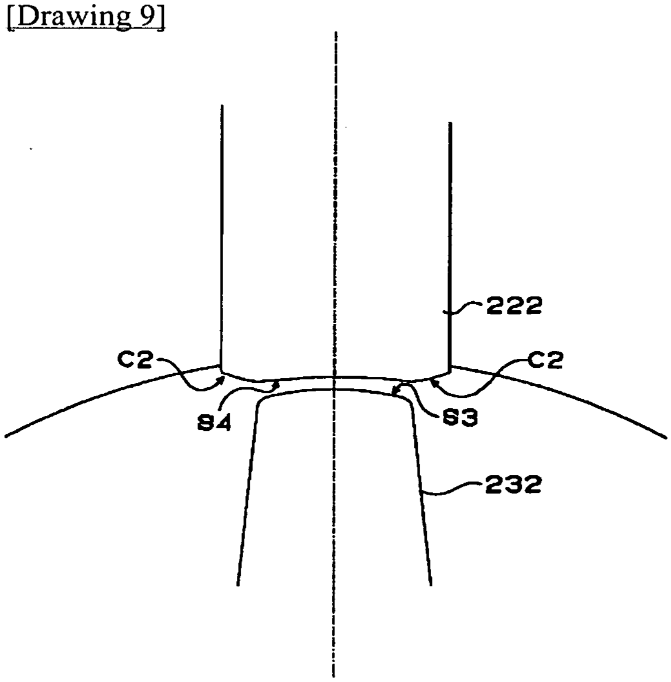
(A)



(B)



[Drawing 9]



[Translation done.]